1wp

THE MINUTE VOLUME OF THE HEART IN VARIOUS TYPES OF BATH

Professor Chr. Kroetz, and Dr. R. Wachter

(NASA-TT-F-15438) THE MINUTE VOLUME OF THE HEART IN VARIOUS TYPES OF BATH (Techtran Corp.) 11 p HC $4.00 CSCL 06P

N74-21702

Unclas

G3/04 36298

Translation of: "Ueber das Minutenvolumen des Herzens in Verschiedenen Baederarten", Klinische Wochenschrift, vol. 12, 1933, pp. 1517-1520.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 APRIL 1974

STANDARD TITLE PAGE

1. Report No. NASA TT F-15,438	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle THE MINUTE VOLUME OF THE HEART IN VARIOUS TYPES OF BATH		5. Report Date April 1974
		6. Performing Organization Code
7. Author(s) Professor Chr. Kroetz and Dr. R. Wachter		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address Techtran Corporation P.O. Box 729, Glen Burnie, Md. 21061		11. Contract or Grant No. NASw-2485
		13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D. C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Translation of: "Ueber das Minutenvolumen des Herzens in Verschiedenen Baederarten", Klinische Wochenschrift, vol. 12, 1933, pp. 1517-1520.

16. Abstract

17. Key Words (Selected by Author(s))	18. Distribution Statement

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	11	4.00

NASA-HQ

THE MINUTE VOLUME OF THE HEART IN VARIOUS TYPES OF BATH

Professor Chr. Kroetz[1,3] and Dr. R. Wachter[2,3]

After the early 1931 report of Sven Roennell [1] on the behavior of the minute volume in thermal brine baths and effervescent baths in Bad Oeynhausen, further investigations on the same question seemed to us both necessary and promising for two reaons. However, we used the freshwater bath as a basis of comparison and extended the investigations to oxygen and pure gas baths. We also believed it advisable to use the acetylene method of Marshal and Grollmann, as introduced by Kroetz, instead of the nitrous oxide method of Krogh and Lindhard. /1517*

While we were conducting our investigations, an informative paper by Bornstein, Budelmann, and Roennell [2] appeared in which the minute volume of a healthy man was determined in plain cold and warm freshwater baths, the natural carbon dioxide brine bath, and upon breathing bath air and air containing CO_2 (0.25 - 0.4% CO_2). We agree with these investigators in regarding all such earlier investigations in the balneological field as no longer decisive since they were performed partly with obsolete techniques and partly on animals, and we thus wish to discuss our own results only by comparison with those of the above-mentioned authors.

Technically, we proceded by determining the basal metabolism twice and then the minute volume (called pre-test) of the sober subject after he had fully rested his muscles for one hour. Then the subject, together with the stretcher on which he had been lying and in exactly the same body position, was lowered by an electric winch into the tub in which the bath had been prepared at the desired temperature. The apparatus was designed to avoid any muscular movement of the subject. After 10 minutes in the bath the basal metabolism and minute volume were taken once again (this is called the bath test), followed by a further determination about 40 minutes after the bath (subsequent period).

*Numbers in the margin are pagination from foreign text.

[1] Frankfurt am Main

[2] Bad Nauheim

[3] Laboratory for Experimental Balneology of the W. G. Kerckhoff Institute of Cardiology, Bad Nauheim

It need scarcely be emphasized that the subjects were in perfect health (examined by x-ray and electrocardiograph), were personally reliable, and all the necessary clinical and technical precautions were strictly observed. With regard to the balneological technique in particular, we worked in the Balneological Laboratory of the Kerckhoff Institute, with the special apparatus according to Groedel and Wachter [3] and used the technique they reported.

In total, 42 bath tests were performed on three subjects with something over 100 determinations of the minute volume. Our subject Sch. who had proved his value for years and the new subject B. were investigated by comparison in all the baths we tested, while our very useful subject E. received only freshwater and CO_2 baths after which he unfortunately withdrew for reasons concerning his job. E. had previously trained as a long distance runner in the German army, which may be the reason why his pulse rate was so slow while he was doing work.

We investigated the minute volume of the heart in neutral lukewarm freshwater, oxygen, carbon dioxide brine, CO_2 gas, and air baths, and it is probable that our measurements in the O_2, CO_2 gas, and air baths are the first ever to have been taken. As already stated, we took the freshwater bath as a basis of comparison in order to exclude any pharmacological effect. Moreover, the temperatures of all baths were chosen such that they were perceived as neither warm nor cool by the subjects. Here, it was observed that the "neutral point" was somewhat different not only from one subject to another, but varied periodically in the same subject, something known from clinical practice. A temperature /1518 perceived as neutral today can be felt to be "a little warm" or "a little cool" tomorrow. We would not waste so many words on this point if it were not of such fundamental importance to exclude a priori such a recognizably significant factor as temperature, and to arrange all the baths in order to compare baths of different chemical natures with one another.

Thus, by keeping the water at a constant level and the stretcher at a constant angle we endeavored to maintain the hydrostatic pressure of the various baths, inasfar as it is dependent on these factors, as constant as possible. These being the pre-conditions, we found for lukewarm freshwater baths (see Table 1) increases of the minute volumes of the various subjects up to 37% whereby on the average subject B. rose only by 5%, Sch. by 20%, and E. by 24%.

As the pulse rate usually sinks somewhat in the bath, the stroke volume was correspondingly somewhat greater. The averages for the above-mentioned subjects were 6%, 24%, and 39% respectively.

These values are significantly lower than those reported by Bornstein, Budelmann, and Roennell, who found an average of 82-85% (once only 44%) for the minute volume and 89-95% for the stroke volume.

The minute volume was influenced more in the lukewarm carbon dioxide brine bath of spring XII (see Table 2). Here we noted increases up to 62% with an average for subject B. of 8% for Sch. of 31%, and for E. of 34%. The percentile stroke volume increases were 8%, 33%, and 48%.

Here also we were struck by the different reactions of the three subjects, just as in the freshwater bath. The minute volume of B. hardly changed in the freshwater or CO_2 bath, nor in the subsequent baths. Thus, none of these neutral baths seemed capable of any substantial impact on his circulation in this sense. On the other hand, Sch. and E. exhibited clear changes even in the freshwater bath, which were considerably greater in the CO_2 bath and parallel quantatively speaking.

The above-mentioned investigators found increases of 24-68% on the average in their carbon dioxide baths but only 43-59% in the effervescent baths, and thus come very near to our results, while their freshwater bath tests gave values about three times those of ours.

It is difficult to see why the freshwater bath, which is chemically quite neutral, should have a greater effect on the circulation than the CO_2 bath, especially as the same authors found in very elegant experiments that carbon dioxide inhalation does not reduce the minute volume at all.

One type of bath which is much closer to the freshwater bath than to the carbon dioxide bath in its effects, inasfar as one may actually speak of "effects", is the oxygen bath (see Table 3). This interpretation of Wachter[4], who /1519 investigated this for gas metabolism changes among others, is also confirmed with respect to the minute volume. We obtained average increases of only 12-18%, although these chemical baths often irritated the subjects considerably by tickling and large bubbles felt to be chilling. Comparisons with our results are not possible unfortunately, since to date no studies have been done on this point by others.

FOLDOUT FRAME

FOLDOUT FRAME 2

TABLE 1. LUKEWARM FRESHWATER BATHS

No.	Name Date 1931	Type of test	In minutes: Bath time	In minutes: Test period	Bath temp.	Min. vol. degrees	Change in liters	Change in%	Pulse	Stroke vol.	Change in cc	Change in%	Body temp.	Skin reaction	Notes
1	Sch.	Pre-test				3.26			72	45.2			36.9	none	Temp. perceived
	5/11	Bath-test	17	11-15	36.0	4.06	+ 0.80	+24	72	56.4	+11.2	+24	36.9		as somewhat warm
2	Sch.	Pre-test				3.39			68	50.0			36.8	none	Completely neutral
	11/11	Bath-test	18	12-16	35.1	3.78	+ 0.39	+11	68	55.6	+ 5.6	+11	36.8		
3	Sch.	Pre-test				3.21			72	44.6			36.8		
	13/11	Bath-test	17	11-15	35	3.99	+ 0.78	+24	64	62.3	+17.7	+39	36.7	none	Completely neutral
4	Sch.	Pre-test				3.15			68	46.3			36.6		
	23/11	Bath-test	17	11-15	35	3.84	+0.69	+22	68	56.4	+10.1	+22	36.4	none	Completely neutral
		Subsq.-test				3.12	-0.03	+0	64	48.7	+ 2.4	+ 5	36.4		
5	B.	Pre-test				3.99			72	55.4			36.3	none	Completely neutral
	16/11	Bath-test	17	11-15	35.2	4.53	+0.54	+13	70	64.7	+ 9.3	+16	36.5		
6	E.	Pre-test				3.48			64	54.3				none	Completely neutral
	23/10	Bath-test	12	6-10	35	4.77	+1.29	+37	56	85.1	+30.8	+56			
7	E.	Pre-test				3.16			60	52.6			36.4	none	Completely neutral
	31/10	Bath-test	17	11-15	35.2	4.09	+0.93	+27	56	73.0	+20.4	+38	36.5		

TABLE 2. CO_2 BATHS WITH SPRING XII, NEUTRAL TEMPERATURE

No.	Name Date 1931	Type of test	In minutes: Bath time	In minutes: Test period	Bath temp.	Min. vol. degrees	Change in liters	Change in%	Pulse	Stroke vol.	Change in cc	Change in%	Body temp.	Skin reaction	Notes
1	Sch.	Pre-test				3.51			68	51.6			36.8	good	Neutral
	6/11	Bath-test	17	11-15	33.1	4.53	+1.02	+29	72	62.8	+11.2	+21	36.4		
2	Sch.	Pre-test				3.23			68	47.5			37	good	Neutral
	10/11	Bath-test	17	11-15	33	4.23	+1.0	+31	68	62.2	+14.7	+31	36.4		
3	Sch.	Pre-test				3.31			68	48.4			37		Froze for undetermined
	12/11	Bath-test	17	11-15	33	3.49	+0.18	+ 5	60	58.0	+ 9.6	+20	36.4		reason; explains small rise?
4	Sch.	Pre-test				3.17			60	52.8			36.8	good	Neutral
	17/11	Bath-test	17	11-15	33.2	5.15	+1.98	+62	60	85.8	+33.0	+62	36.1		

FOLDOUT FRAME

FOLDOUT FRAME 2

TABLE 2. CO_2 BATHS WITH SPRING XII, NEUTRAL TEMPERATURE (CONT.)

No.	Name Date 1931	Type of test	In minutes: Bath time	In minutes: Test period	Bath temp.	Min. vol.	Change: in liters	Change: in%	Pulse	Stroke vol.	Change: in cc	Change: in%	Body temp.	Skin reaction	Notes
5	B.	Pre-test				4.27			72	59.3			36.6	good	Neutral
	14/11	Bath-test	17	11-15	33	4.58	+0.31	+ 7	68	67.3	+ 8.0	+13	36.3		
6	E.	Pre-test				3.48			60	58			36.8	strong	Neutral
	22/10	Bath-test	12	6-10	33	4.32	+0.84	+24	52	83	+25	+43	36.4		
7	E.	Pre-test				3.02			60	50.3			36.9	strong	Neutral, somewhat cool at beginning only
	28/10	Bath-test	17	11-15	32.5	4.35	+1.33	+44	56	77.6	+27.3	+54	36.4		

TABLE 3. O_2 BATHS, NEUTRAL TEMPERATURE

No.	Name Date 1931	Type of test	In minutes: Bath time	In minutes: Test period	Bath temp.	Min. vol.	Change: in liters	Change: in%	Pulse	Stroke vol.	Change: in cc	Change: in%	Body temp.	Skin reaction	Notes
1	Sch.	Pre-test				3.13			72	43.4			36.6	none	somewhat cooling sensation fluctuating due to the bubbles
	26/11	Bath-test	17	11-15	35.5	3.56	+0.43	+13	68	52.3	+ 8.9	+20	36.7		
2	Sch.	Pre-test				2.75			68	40.4			36.5	none	Neutral
	28/11	Bath-test	17	11-15	35.3	3.41	+0.66	+24	68	50.1	+ 9.7	+24	36.5		
3	B.	Pre-test				3.47			72	48.9			36.4	none	"tickles" more than CO_2 bath
	27/11	Bath-test	17	11-15	35.1	3.81	+0.34	+10	72	53.0	+ 4.9	+12	36.4		
4	B.	Pre-test				3.19			72	45.4			36.5	none	Neutral
	29/11	Bath-test	17	11-15	35.5	3.68	+0.49	+15	68	51.1	+ 8.7	+19	36.5		

From the "water bath" in its various forms we proceeded to the carbon dioxide gas bath (see Table 4), in which the carbon dioxide was not dissolved in water but was used in the free gas state, "dry", or "moist".[4] In the dry gas bath the natural carbon dioxide gas, obtained from the effervescent spring of Bad Nauheimer and collected in a large gas container, was piped directly into the special tub. For the moist bath the gas first passed through an apparatus built specially for the occasion in which it was brought to a lukewarm temperature and saturated with water vapor. The technical details are beyond the scope of this paper. It will merely be noted that we developed the technique published on a previous occasion.

In these baths the stroke volume of subject B. increased by 6.5% on the average, and that of subject Sch. by 8.5% - a very moderate increase. The stroke volumes of 3.5% and 10% are scarcely greater than experimental error. In addition, in 10 tests there was no change whatever in one case and in two cases the minute volume was even smaller, and in the "moist" bath as well. Moreover, since bath No. 6 is shown in Table 4, although it is somewhat too hot and therefore causes a rise of 17%, causing an artificial rise in the average value. No. 6 is included only to show how a temperature somewhat higher than neutral temperature immediately changes the result.

Our results suggest than the carbon dioxides alone, at least in this form of application, influence the minute volume of the heart only slightly or not at all, although three limitations must be imposed. The reaction cannot indeed be so great as in the CO_2-water bath since 1) the CO_2 concentration gradient in the direction bath → skin (body) is not so great; 2) the pores of the skin are not so closed as in water; and 3) the hydrostatic pressure diminishes. Perhaps a greater change could have been achieved here too if the bath were prolonged and at higher concentration.

In other respects, these results once more coincide with those of Groedel and Wachter in their gas metabolism investigations. In these too the maximum respiratory quotient was observed in the CO_2 brine bath, as was the strongest skin reaction.

---

[4]In the literature the term gas bath is used in the sense of water baths containing gas as opposed to those not containing gas.

Finally, for completeness, an air bath (see Table 5) is shown which predictably had no effect.

The after-effect of the baths was investigated nine times. An effect was usually found 40 minutes after the CO_2 brine bath, and there was no subsequent effect with the other baths.

SUMMARY

Determinations of the minute volumes of the hearts of three healthy subjects who took five different kinds of baths gave the following results:

1. In the freshwater bath the minute volume increased distinctly but not by any great amount. We may call the average value 20-24%. Here and in all the other types of bath there were unmistakable and consistent differences between the individual reactions of the subjects.[5]

2. In the carbon dioxide brine bath from Bad Nauheim spring No. XII we obtained somewhat higher values, between 31% and 34% on the average.

3. In the oxygen bath the minute volumes of the subjects increased by an average of 12-18%. Thus, the oxygen bath is to be placed next to the freshwater bath and not to the carbon dioxide bath with respect to the minute volume.

4. In the carbon dioxide gas bath we observed increases of only about 6-8%, for the reasons explained in greater detail above.

5. The air bath gave no reaction.

The time periods immediately following the baths, in which the minute volume returned to normal with variable speed, was investigated once again. Only with /1520 the CO_2 brine bath was the minute volume higher on some occasions as late as 40 minutes after the bath - another proof of the more prolonged effect of the natural CO_2 bath.

[5] In order to state the average values without further explanation, we excluded subject B. from the data in the summary.

FOLDOUT FRAME 1

FOLDOUT FRAME 2

TABLE 4. NATURAL CO_2 GAS BATHS, NEUTRAL TEMPERATURE

No.	Name Date 1931	Type of test	In minutes		Bath temp.	Min. Vol.	Change		Pulse	Stroke vol.	Change		Body temp.	Skin reaction	Notes
			Bath time	Test period			in liters	in%			in cc	in%			
1	Sch.	Pre-test				2.70			68	40			36.6	none	No special sensations
	2/12	Bath-test	17	11-15	25	3.12	+0.42	+15	68	45.8	+ 5.8	+14	36.5		
2	Sch.	Pre-test				3.16			64	50			36.5	none	Neutral, dry gas
	3/12	Bath-test	17	11-15	27	3.17	+0	+0	61	52	+ 2.0	+ 4	36.4		
3	Sch.	Pre-test				3.09			72	42.9			36.5	some	
	5/12	Bath-test	17	11-15	28	3.45	+0.36	+11	68	50.7	+ 7.8	+18	36.5	redening	Neutral, moist gas
4	Sch.	Pre-test				2.65			64	41.4			36.5	uncertain	Neutral, moist gas
	9/12	Bath-test	17	11-15	28	3.03	+0.38	+14	64	47.3	+ 5.9	+14	36.4		
5	Sch.	Pre-test				2.68			64	41.8			36.52	slight	"tingling", expecially
	11/12	Bath-test	17	11-15	28	2.54	-0.15	-5	60	42.3	+ 0.5	+1	36.35		between legs and testes
6	Sch.	Pre-test				3.04			62	49.0			36.68	slight	somewhat too warm
	16/12	Bath-test	23	11-20	30	3.58	+0.54	+17	68	52.6	+ 3.6	+7	36.5		
7	B.	Pre-test				3.03			72	42.0			36.5	none	Neutral
	4/12	Bath-test	17	11-15	25	3.48	+0.45	+15	68	51.1	+ 9.1	+21	36.2		
8	B.	Pre-test				3.00			66	45.4			36.5	on the	
	8/12	Bath-test	17	11-15	29	3.23	+0.23	+7	74	43.6	- 1.8	-4	36.5	legs	
9	B.	Pre-test				2.60			76	34.2			36.2	uncertain	nose clamp pinched;
	10/12	Bath-test	17	11-15	29	2.81	+0.21	+8	80	34.7	+ 0.5	+1	36.2		neutral; body moist
10	B.	Pre-test				2.93			72	40.7			36.18	arms and	Strong tingling at
	12/12	Bath-test	17	11-15	31	2.81	-0.12	-4	72	39.0	- 1.7	-4	36.12	legs	beginning; skin somewhat moist

TABLE 5. AIR BATH, NEUTRAL TEMPERATURE

No.	Name Date 1931	Type of test	Bath time	Test period	Bath temp.	Min. Vol.	Change in liters	in%	Pulse	Stroke vol.	Change in cc	in%	Body temp.	Skin reaction	Notes
	Sch.	Pre-test				3.04			68	44.7			36.6	none	Neutral
	14/12	Bath-test	17	11-15	28	2.99	-0.02	-1	68	44.0	- 0.7	-1	36.5		

REFERENCES

1. Roennell, S., *Arch. med. scand.*, No. 74, p. 334, 1931.
2. Bornstein, A., Budelmann, G., and Roennell, S., *Z. klin. Med.*, No. 118, p. 596, 1931.
3. Groedel and Wachter, Salzuflen Balneological Congress, 1931, *Z. f. Kurortwissenschaft;* also *Z. wiss. Baederk.*, Published Zentralstelle f. Balneol., N.F.H. 16.
4. Wachter, R., *Z. Kreislaufforsch.*, Vol. 23, p. 314, 1931.

Translated for the National Aeronautics and Space Administration under contract No. NASw-2485 by Techtran Corporation, P.O. Box 729, Glen Burnie, Maryland, 21061, translator: William J. Grimes, M.I.L.